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ABSTRACT

Recent reports indicate that although 17-year-old high school students know some basic addition and subtraction facts, few of the students are capable of solving multi-step mathematics problems. A non-equivalent pretest-posttest control group design study examined the effects of a teaching method emphasizing manipulative use on the mathematics achievement of third-grade students. Two third-grade classes with 26 students each were selected to participate in the study. Reported demographic data indicated that the control group class from western Iredell County was composed of 10 (38%) white male students, 3 (12%) black female students, and 13 (50%) white male students, and that the experimental group class from southern Iredell County was composed of 10 (38%) white male students and 16 (62%) white female students. A 2-week geometry unit from the Silver Burdett textbook was administered in both classes. The experimental group teacher used mathematics manipulatives to teach the concepts presented in the unit, and the control group teacher used only drawings and diagrams to teach concepts. Analysis of covariance revealed that the experimental group using mathematics manipulatives scored significantly higher in mathematics achievement on the posttest scores than the control group. Further study is recommended to see if this finding is generalizable beyond the two classes studied or the subject of geometry. The pretest and the posttest are attached. (MDH)

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Math Manipulatives Use and Math Achievement of Third Grade Students

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Running Head: MATH MANIPULATIVES

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Abstract

The purpose of this study was to investigate the effect of math manipulatives on the gains in math achievement of third grade students in two Iredell County Schools. The study tested three hypotheses. The first two hypotheses stated a significant difference would be found between the pretest and posttest scores of the experimental group and of control group. The third hypothesis stated a significant difference would be found between the posttest scores of the control group and the experimental group.

The source group consisted of two third grade classrooms, each with twenty-six students. The students were randomly selected by the principals of the schools to be placed in each classroom. The students are not grouped according to ability or achievement levels. The study was conducted using the non-equivalent pretest-postest control group design. The major statistics were Analysis of Covariance and t-test. The study concluded that a significant difference was found in the pretest and posttest scores of each group and between the posttest scores of the two groups.

Introduction

The Association for the Supervision of Curriculum Development (1990) recently reported that in the area of mathematics, while 100% of seventeen-year-old high school students know some basic addition and subtraction facts,and are capable of adding and subtracting two-digit numbers, only 6% can solve multi-step math problems.

Much of the failure of mathematics in American schools is due to teaching practices that do not take into consideration the learning styles of each student (National Research Council, 1989). Using math manipulatives is one method of teaching that makes learning math real to students.

Math manipulatives are appropriate for all grade levels, kindergarten through eighth grade, and are adaptive to many topics and ability levels of students. Lessons in which teachers use math manipulatives have a higher probability of achievement than traditional lessons (Suydam, 1984).

This study is important because it supports other current research which indicate the use of math manipulatives increase math achievement.

Problem Statement and Hypotheses

The purpose of this study was to investigate the effect of math manipulatives on gains in math achievement of third grade students in two Iredell County schools.

The study was based on three hypotheses. First, there is a significant difference ($p \leq .05$) between the pretest scores and the posttest scores of the control group. There is also a significant differnce ($p \leq .05$) between the pretest and posttest scores of the experimental group. Most importantly, there is a significant difference ($p \leq .05$) between the posttest scores of the control group and the posttest scores of the experimental group.

Theoretical Framework

This study is based on the work of Jean Piaget. Piaget's theory involves two types of experiences - physical and logico-mathematical. Physical knowledge is knowledge gained from observation of objects. The process of acquiring physical knowledge is called empirical abstraction. Logico-mathematical knowledge comes not from the objects, but from the action of the learner on the objects. Another name for logico-mathematical knowledge is reflective abstraction.

Piaget's theory involves four basic stages of development. The stages are sensori-motor, preoperational, concrete-operational, and formal operational. In each stage, individuals must organize information (assimilation) and adapt that information to fit into the individual's environment (accomodation). The schemes are constantly being brought into equilibrium with the individual's environment (equilibration). At each stage, the individual has a different kind of psychological structure with which to deal with each situation.

In the elementary school, educators deal with children in the preoperational and concrete-operational stages. These two stages involve children from the approximate ages of two years to eleven years. Educators must be aware of that all children pass through all the stages, but each child will pass through the stages at different times. A child's progression within and between the stages is achieved by interaction between objects and the discovery of their properties (empirical abstraction) and the constructing of the rules through manipulation of the objects (reflexive abstraction).

Review of Literature

The teaching of mathematics and students' achievement in this area are receiving national attention. In Everybody Counts - A Report to the Nation on the Future of Mathematics Education, (Mathematical Sciences Education board, 1989) teachers are reminded that mathematics today involves more than mere calculation. It involves finding patterns, testing theories, and estimating results. Students need to be encouraged to learn mathematics by processes of mental construction and experience. Elementary school mathematics should access children's natural curiosities about patterns and their world.

In 1988, the National Council of Teachers of Mathematics published standards for teaching school mathematics. The Council suggested a greater emphasis be placed on problem solving, mathematical reasoning, measurement, geometry, estimation, statistics, and probability. How do they propose teachers accomplish this? Teachers must de-emphasize paper and pencil activities and focus on the exploration of mathematics through manipulatives, measuring devices, models, calculators, and computers.

The review of literature was conducted in the areas of the use of concrete materials, the teachers use and knowledge of math manipulatives, the use of math manipulatives in various areas of mathematics, the use and study of math manipulatives in geometry, and reccomendations for teachers using math manipulatives. The review was based on articles and papers presented in professional journals.

The Use of Concrete Materials

With increasing emphasis being placed on achievement and teaching practices in the area of mathematics, the use of math manipulatives has become one of the foremost topics in mathematics education today. According to Baroody (1989) mathematics instruction should begin with experiences that are real to the student. Then, instruction can proceed to the symbolic levels. This theory is based on the five modes of presentation of concepts. The first and second modes of using real world situations and manipulative models are crucial for meaningful learning. The third mode, pictures and diagrams, can be used to bridge the gap between concrete and abstract concepts. Finally, spoken and written symbols may be used to teach concepts.

Teachers Knowledge and Use of Math Manipulatives

Most current research supports the use of math manipulatives, and a survey conducted by Gilbert and Bush (1988) found that teachers are familiar with math manipulatives and these are available to them for use in the classroom. The specific math manipulatives referred to in the survey included twenty-five materials ranging in complexity from counters and Cuisenaire rods to protractors and calculators. The survey findings concluded that the use of math manipulatives decreased as the grade level increased and the number of years teaching experience was inversely related to the use of math manipulatives.

Scott (1983) had similar findings when surveying urban school teachers. He also noted a steady decline in the use of math manipulatives with increases in the the ages of the students. He found that measurement materials were used fairly equially in all grade levels. The use of compasses, protractors and calculators increased as students reached upper grades. Scott also noted that teachers with recent training tended to use math manipulatives and those teachers who relied less on textbooks used math manipulatives more often.

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Math Manipulatives Use in Various Topics

Math manipulatives have long been used in teaching counting and number concepts to primary age children. Many teachers are unaware of the appropriateness of using math manipulatives across subject areas. Suydam (1984) noted that math manipulatives are adaptive at every grade level, achievement level, ability level, and across a wide variety of topics.

In Teaching Mathematics in the Elementary School (Nesbit, Margolian, Pearson, 1970), the authors presented ways of utilizing math manipulatives in the classroom. Geometric shapes help children see patterns and solutions to problems. They can be used in teaching classification and number skills. Geoboards are useful in learning direction, visual perception, properties of geometry, and rational number theory. Number lines have been primarily used in counting, sequencing, and mastering the four basic operations. However, in the upper grades, number lines help students learn about fractions, decimals, and negative numbers. An abacus is an excellent tool for teaching place value. Using math manipulatives such as these help students learn from concrete examples and are then better equipped to deal with abstract concepts.

Study of Geometry and Math Manipulatives Use

In elementary schools, the primary focus of geometry is two-fold. The students deal mainly with the recognition of shapes and the related vocabulary (Suydam, 1985). Children must be able to interact with various shapes in order for the child tobe able to abstract the given shape(Copeland, 1984). However, geometry is much more than that. Geometry helps children learn to organize and structure their spatial relationships, and develop mathematical reasoning abilities (Burger, 1985).

Primary children are better able to learn geometric concepts when they handle geometric solids or models (Suydam, 1985). Utilizing the sense of touch instead of sight helps children develop mental images of shapes (Juraschek, 1990). This is easily achieved through the use of "Mystery Bags". Using bags filled with tangram pieces, pattern blocks, and geometric blocks, students reach in the bag and work to identify the shapes by using only their sense of touch.

Instruction of geometry using math manipulatives leads to a coherence of ideas of space, solid figures, and plane figures (Pappas and Bush, 1989). Studying first grade learners using Cuisenaire rods and tangram pieces, Pappas

and Bush outlined teaching strategies for Learning Encounters. While Cuisenaire rods were available for daily play, the teacher would assign specific tasks such as building a cube from the rods. The students used tangram pieces to make squares from triangles or rectangles from squares. The findings suggested two practices for any teaching using math manipulatives. First, the activities should emphasize the children's need to construct their own knowledge. Second, the teacher's role should be one of interviewer and observer.

Reccomendations for Teachers

To ensure positive results when using math manipulatives, thoughtful planning on the part of the teacher is required. The classroom climate should be nonthreatening. Teachers must encourage students to ask questions and take risks (National Council of Supervisors of Mathematics, 1989). Teachers should ensure that the objects are real and familiar to the students. Simple objects such as shells, buttons, and clothespins are frequently used as counters (Nesbit, Margolian, Pearson, 1970). The teacher should plan activites that enable the learners to connect the new knowledge with existing knowledge, therefore making

it meaningful to them. The activities should require the students to reflect or think (Baroody, 1989). Watching the teacher use math manipulatives can be as effective as the learning using them alone or in groups. This helps the students focus on important mathematical ideas (Suydam, 1984). Concrete manipulation of math manipulatives should preceed the naming or symbolic representations of new concepts (Driscoll, 1984). When teaching geometric shapes, teachers should vary the representations of the shapes. For example, identical triangles should ber turned on each side and vertex (Suydam, 1985).

In summary, the use of math manipulatives should increase student achievement in the area of mathematics. Understanding is retained longer through discovery. Exploration and discovery requires teachers to spend time examining the cognitive structures of the concepts and then to create appropriate experiences in which students can discover these concepts (Simon, 1986). Using math manipulatives require students to actively do math instead of passively complete paper and pencil activities. Concrete materials help students understand concepts by helping them understand the reasons for the rules, not just applying them (Burns,1986)

Research Design

The study was conducted using the non-equivalent pretest-posttest control group design. This method was chosen due to the inability to divide existing classroom groups. Both groups were administered a pretest before any instruction began. After completing the unit of study, each group was given the unit posttest. The only definite weakness in this design is the possible interaction between the pretest and the instruction. The students may benefit from taking the pretest and the results may not reflect the true nature of the instruction. Other possible threats to the internal validity of the research may include the presence of outside tutors or parents who tutor their children at home. This may give unreliable results. External validity may be threatened due to the ungeneralizability of the results. The results should only be compared to other groups if those groups are pretested. A limitation of this research is the lack of verification given by Silver-Burdett on its measures of validity and reliability, although content validity is established through the use of objectives. The adjusted posttest scores of the two groups were analyzed using ANCOVA. The

content validity was established through the use of lesson objectives being matched to test items. (See Tabel 1). The tests were appropriate because they follow the lesson objectives and format of the text, and are based on skills appropriate for the third grade level. The tests were chosen due to the availability and appropriateness for this research study.

Procedures

The study, conducted in classes at Mt. Mourne Elementary and Celeste Henkel Elementary, began February 1, 1991. Prior to beginning instruction in the unit on geometry, the students in both groups were given the multiple-choice unit pretest. This test was part of the resource materials issued by the textbook's publisher, Silver Burdett. From February 1-15, the groups completed the same geometry unit, using the textbook pages for independent practice. Each math session lasted approximately one hour. The teacher of the experimental group used math manipulatives to teach the concpets presented in the unit. (See Table 2).

The teacher of the control groups used only drawings and diagrams to teach the concepts. (See Table 3). At no

pretest-posttest scores of each group were analyzed using a T-test.

Source Group

The source group consisted of two third grade classrooms, each with twenty-six students. The students were randomly selected by the principals of the participating schools at the beginning of the school year. The students were not placed according to ability or achievement levels. The control group was assigned to Celeste Henkel School in western Iredell County. The class included 10 (38%) white male students, 3 (12%) black female students, and 13 (50%) white female students for a total of twenty-six students. The experimental group was assigned to Mt. Mourne School in southern Iredell County. The class included 10 (38%) white male students, and 16 (62%) white female students for a total of twenty-six students.

Instrumentation

The students were pretested and posttested using the multiple choice tests that accompany the Silver-Burdett math series (Silver Burdett, 1987). Reliability and validity information was not available from the publisher. However,

time during the study were the students allowed to manipulate models or use other math manipulatives. However, at the end of the study, the students in the control group were given opportunities to use math manipulatives to reinforce the concepts presented in the unit.

At the end of the two-week instruction period, both groups were given the multiple-choice posttest supplied by Silver Burdett.

Research Findings and Results

In regards to the first hypothesis, a significant difference ($t = -14.92$, $p = .000$) was found between the pretest and posttest scores of the control group. (See Table 4). In addition, a significant difference ($t = -15.06$, $p = .000$) was found between the pretest and posttest scores of the experimental group. (See Table 5). The most important finding, a significant difference ($f = 5.68$, $p = .021$) was found between the adjusted posttest scores of the control group and the experimental group. (See Table 6).

Discussion, Conclusions and Implications

Given the statistical information, each hypothesis was proven correct. A significant difference was found between the pretest and posttest scores of each group. In addition,

the experimental group, which used the math manipulatives, received higher adjusted posttest scores than the control group, which used only the textbook. The use of math manipulatives will increase the achievement of third grade students. These findings indicate that this may be true for other third grade students in Iredell County Schools who use the Silver Burdett textbook. The use of math manipulatives may also be beneficial to students studying other areas of math, not just geometry. Further research would be necessary to justify both of these generalizations. An ideal study might include a year-long program involving a larger sample, covering more topics. The results of this study may provide teachers with information needed to encourage them to use math manipulatives as a part of the math program.

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Appendix

Table 1

Verification of Content Validity

Management Objectives	Pre/posttest items
Identify space figures	5-8
Identify geometric figures	9-12
Identify congruent, symmetric figures	13-16
Find perimeter, area, volume	17-21
Use ordered pairs to locate points	1-4
Use guess and test strategy	22-25

Table 2

Manipulative Activity/Materials

Objective	Activity/Materials
Identify space figures	3-D figures
Identify plane figures	geoboards and bands shape pictures sponge painting toothpicks
Congruent and symmetric figures	cutting shapes match relationshapes mirrors pattern blocks
Find the area, volume, and perimeter	Cuisennaire rods relationshapes unifix cubes geoboards and bands
Use ordered pairs to locate points on a grid	local map with grid decoding messages
Use guess & test strategy	relationshapes

Table 3

Textbook Activities

Objective	Activity
Identify space figures	Look for relevant examples in the classroom to correspond with pictues in the textbook.
Identify plane figures	Draw examples of plane figures on the board for the students to identify.
Congruent and symmmetric figures	Draw figures on the board and have the students identify which are congruent. Write the letters of the alphabet on the board and look for those which are symmetric.
Find the area, volume, and perimeter	Use drawings to illustrate square and cubic units to measure area and volume. Give illustrations of

	figures with the measurement of each side given.
Use ordered pairs to locate points on a grid	Draw grid on the board and label points with letters. Ask students to identify coordinates of letters.
Use guess & test strategy	Work through sample problems with students in small groups.

Table 4

Textbook Pretest-Posttest

	Mean	SD	t Value	p Value
Pretest	52.62	12.22		
			-14.92	.000
Posttest	81.54	9.54		

$p \leq .05$

Table 5

Manipulative Pretest-posttest

	Mean	SD	t Value	p Value
Pretest	51.92	11.01		
			-15.06	.000
Posttest	86.62	8.54		

$p \leq .05$

Table 5

Experimental Group vs. Control Group: Posttest Scores

	Mean	SD	t Value	p Value
Experimental	86.62	8.54		
			5.68	.021
Control	81.54	9.54		

$p \leq .05$

Definitions of Terms

Math manipulatives : Anything that the student can physically or mentally move in order to discover the solution to a problem

Control group : The group which received instruction from the textbook only.

Experimental Group : The group which received instruction using manipulatives as well as with the textbook.

Textbook Instruction : Silver Burdett, Level 3, Chapter 13:Geometry

Manipulatives and Textbook Instruction: The textbook instruction plus the added use of math manipulatives

Limitations

Several limitations are appropriate for this study. First, the study took place over a two week period. A longer study, covering more topics than just geometry may produce more generalizable results. Second, the source group were the pre-existing classes at Mt. Mourne and at Celeste Henkel. The results may vary if the sample was larger and more diverse. Last, the lack of verification on the reliability and validity may be a limitation. Several attempts were made to reach Silver Burdett. However, the information received from the company was not what was requested. Content validity was established, however, through the matching of lesson objectives to the test items.

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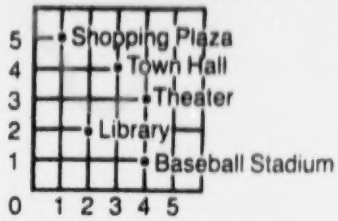
Name _____ **CHAPTER 13 PRETEST**

Choose the correct answer for each.

Use the map below to answer 1–4.



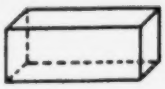
1. What is located at (4,3)?
   - A town hall
   - B theater
   - C baseball stadium
   - D not given

2. What is located at (1,5)?
   - A shopping plaza
   - B baseball stadium
   - C library
   - D not given

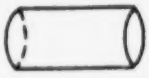
3. Where is the town hall?
   - A (3,4)
   - B (4,3)
   - C (2,5)
   - D not given

4. Where is the library?
   - A (3,3)
   - B (1,5)
   - C (2,2)
   - D not given

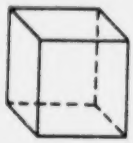
Choose the correct name for 5–8.

5. 
   - A cylinder
   - B cube
   - C rectangular prism
   - D not given

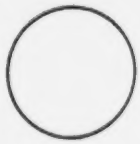
6.
   - A cone
   - B sphere
   - C cube
   - D not given

7. 
   - A sphere
   - B cone
   - C rectangular prism
   - D not given

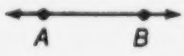
Choose the correct name.

8. 
   - A sphere
   - B rectangular prism
   - C cube
   - D not given

Choose the correct name for each plane figure for 9–12.

9. 
   - A square
   - B circle
   - C rectangle
   - D not given

10.
    - A triangle
    - B square
    - C circle
    - D not given

11. 

    - A line
    - B line segment
    - C ray
    - D not given

12.

    - A angle
    - B line segment
    - C ray
    - D not given

13. Which dotted line is a line of symmetry?
    - A
    - B
    - C
    - D not given

Choose the figure that is congruent to the plane figure shown for 14–15.

14.
    - A
    - B
    - C
    - D not given

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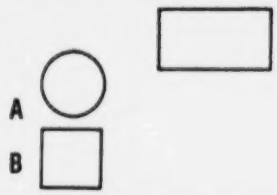
GO ON

32

Choose the correct answer for each.

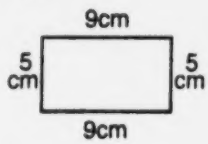
15. 

A
B
C
D not given

16. Which figure has *no* line of symmetry?

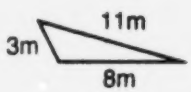
A
B
C
D not given

17. What is the perimeter of this figure?



A 26 cm
B 28 cm
C 14 cm
D not given

18. What is the perimeter of this figure?

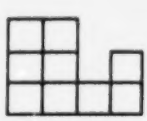


A 22 m
B 19 m
C 33 m
D not given

19. What is the area of this figure?

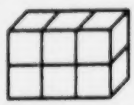
A 8 square units
B 2 square units
C 4 square units
D not given

20. What is the area of this figure?



A 8 square units
B 12 square units
C 10 square units
D not given

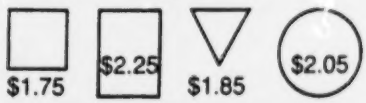
21. What is the volume of this figure?



A 12 cubic units
B 6 cubic units
C 11 cubic units
D not given

Guess and test to solve 22–23.

22. The store had 4 different shapes of posters.



Ed bought 2 posters. He spent $3.60. Which 2 did he buy?

A rectangle/circle
B square/triangle
C rectangle/triangle
D not given

23. Robin has 60 stickers. All of her stickers are triangular or rectangular. She has 8 more triangles than rectangles. How many triangles does she have?

A 26 B 38 C 34 D not given

Solve.

24. Carlos made a rug out of red and blue wool. He spent $3.20 on the red wool. The wool cost $6.10 altogether. How much did Carlos spend on the blue wool?

A $9.30 C $2.90
B $3.10 D not given

25. The rug is a square. Each side is 120 cm. What is the perimeter of the rug?

A 480 cm C 240 cm
B 120 cm D not given

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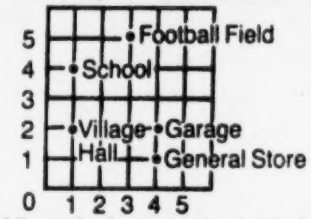
STOP.

Name _____ **CHAPTER 13 POSTTEST**

Choose the correct answer for each.

Use the map below to answer 1–4.



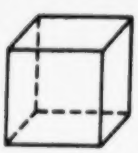
1. What is located at (4,1)?
   - A garage
   - B school
   - C general store
   - D not given

2. What is located at (3,5)?
   - A garage
   - B football field
   - C village hall
   - D not given

3. Where is the village hall?
   - A (3,3)
   - B (3,5)
   - C (4,4)
   - D not given

4. Where is the school?
   - A (1,4)
   - B (4,1)
   - C (2,3)
   - D not given

Choose the correct name for 5–8.

5. 
   - A sphere
   - B rectangular prism
   - C cube
   - D not given

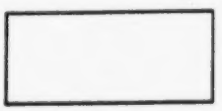
6.
   - A cone
   - B cylinder
   - C sphere
   - D not given

7.
   - A cube
   - B cone
   - C rectangular prism
   - D not given

8.
   - A sphere
   - B cylinder
   - C cube
   - D not given

Choose the correct name for each plane figure for 9–12.

9.
   - A circle
   - B rectangle
   - C triangle
   - D not given

10. 
    - A triangle
    - B rectangle
    - C square
    - D not given

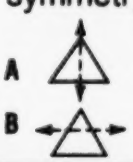
11.

    - A line segment
    - B ray
    - C line
    - D not given

12.

    - A ray
    - B angle
    - C line segment
    - D not given

13. Which dotted line is a line of symmetry?



D not given

Choose the figure that is congruent to the plane figure shown for 14–15.

14.

D not given

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GO ON.

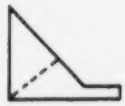
Name _____ **CHAPTER 13 POSTTEST**

Choose the correct answer for each.

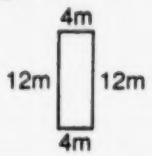
15.

A
B
C
D not given

16. Which figure has *no* line of symmetry?

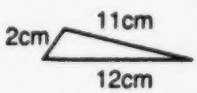
A
B
C 
D not given

17. What is the perimeter of this figure?



A 34 m
B 32 m
C 16 m
D not given

18. What is the perimeter of this figure?

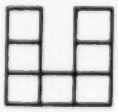


A 22 cm
B 23 cm
C 25 cm
D not given

19. What is the area of this figure?

A 6 square units
B 3 square units
C 12 square units
D not given

20. What is the area of this figure?



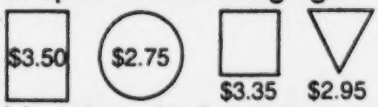
A 7 square units
B 9 square units
C 6 square units
D not given

21. What is the volume of this figure?

A 8 cubic units
B 4 cubic units
C 9 cubic units
D not given

Guess and test to solve 22–23.

22. An art store has 4 different shapes of wall hangings.



Mark bought 2 wall hangings for his room. He spent $6.10. Which 2 wall hangings did he buy?

A triangle/rectangle
B square/triangle
C circle/square
D not given

23. Linda has 40 buttons. All of her buttons are square or circular. She has 6 more squares than circles. How many squares does she have?

A 17 B 26 C 23 D not given

Solve.

24. Amy bought 4 meters of ribbon to trim a sweater. The ribbon sells for $1.25 a meter. How much did she pay for the ribbon?

A $4.00 C $3.75
B $6.00 D not given

25. Amy bought 2.4 m of red ribbon and 1.6 m of white ribbon. How much more red ribbon did she buy?

A 1.2 m C 0.8 m
B 1.8 m D not given

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STOP.